

How Ecosystems Change

Ecosystems are constantly changing. A forest hundreds of years old may have been a shallow lake a thousand years ago. A dead tree falls and lets sunlight reach the forest floor. The sunlight allows dormant or new seeds to germinate, and soon wildflowers and shrubs cover the forest floor. Mosses, shrubs, and small trees cover the concrete of a demolished city building. These are all examples of an environmental change called ecological succession.

Ecological Succession

Ecological succession is a gradual process of change and replacement of some or all of the species in a community. Ecological succession may take hundreds or thousands of years. Each new community that arises makes it harder for the previous community to survive. If given enough time, communities may stop changing for long periods of time. Small changes will continue to happen, but eventually a community can become stable. American beech trees, shown in **Figure 3.1**, are a species found in a stable community.

Succession can occur in areas that previously did not support life, such as on rocks or sand dunes. This type of succession is called **primary succession**. A more common type of succession, called **secondary succession**, occurs in areas where an ecosystem has previously existed. For example, ecosystems that have been disturbed or disrupted by humans or animals, or by natural processes such as storms, floods, and earthquakes can regrow through secondary succession.

FIGURE 3.1

Ecological Succession American beech trees are a stable community species, establishing themselves in a given region.



Objectives

- ▶ List two types of ecological succession.
- ▶ Explain how a pioneer species contributes to ecological succession.
- ▶ Describe how lichens contribute to primary succession.
- ▶ Explain what happens during old-field succession.

Key Terms

ecological succession
primary succession
secondary succession
pioneer species
climax community

CHECK FOR UNDERSTANDING

Compare How is secondary succession different from primary succession?

FIGURE 3.2

Pioneer Species Over a long period of time, lichens can break down rock into soil.



Primary Succession

Primary succession can occur on new islands created by volcanic eruptions, in areas exposed when a glacier retreats, or on any other surface that has not previously supported life. Primary succession is much slower than secondary succession because primary succession begins where there is no soil. It can take several hundred to several thousand years to produce fertile soil naturally. Imagine that a glacier melts and exposes an area of bare rock. The first species to colonize the bare rock will most likely be bacteria and lichens, which can live without soil. A species that colonizes an uninhabited area and begins the process of ecological succession is called a **pioneer species**. Lichens, shown in **Figure 3.2**, are important pioneer species in primary succession. They are the colorful, flaky patches that you see on trees and rocks. A lichen is a producer that is actually composed of two different species, a fungus and green algae or cyanobacteria. The algae or the cyanobacteria photosynthesize, while the fungus absorbs nutrients from rocks and holds water. Together, they begin to break down the rock.

CASESTUDY

Communities Maintained by Fire

Fires set by lightning or human activities occasionally sweep through large areas. Burned areas undergo secondary succession. In the forests of the Rocky Mountains, for example, burned areas are rapidly colonized by fireweed, which clothes the slopes with purple flowers. In some places, fire determines the nature of the climax community. In the United States, ecological communities that are maintained by fire include the chaparral of California, the temperate grassland of the Midwest, and many southern and western pine forests.

Plants native to these communities are adapted to living with fire. A wildfire that is not unusually hot may not harm fire-adapted pine trees, but it can kill deciduous trees—those trees that lose their leaves in winter. Seeds of some species will not germinate until exposed to temperatures of several hundred degrees. When a fire sweeps through a forest, the fire kills plants on the ground and stimulates the seeds to germinate.



Fireweed is one type of plant that colonizes land after the land has been burned by fire.

Longleaf pines have a strange growth pattern. When they are young, they have long needles that reach down to the ground. The trees remain only about a half of a meter high for many years, while they store nutrients. If a fire occurs, it sweeps through the tops of the tall trees that survived the last fire. The young longleaf pines near the ground may escape the fire. Then, the young pines use their stored food to grow very rapidly. A young pine can grow as much as 2 m each year. Soon the young pines are tall enough so that a fire near the ground would not harm them.

If regular fires are prevented in a fire-adapted community, deciduous trees may invade the area. These

As the growth of the lichen breaks down the rock, water may freeze and thaw in cracks, which further breaks up the rock. Soil slowly accumulates as dust particles in the air are trapped in cracks in the rock.

Dead remains of lichens and bacteria add to the soil in the cracks. Mosses may increase in number and break up the rock even more. When the mosses die, they decay and add nutrients to the growing pile of soil. Thus, fertile soil forms from the broken rock, decayed organisms, water, and air. Primary succession can also be seen in any city street, as shown in **Figure 3.3**. Mosses, lichens, and weeds can establish themselves in cracks in a sidewalk or building. As well, fungi and mosses can invade a roof that needs repair. Even a big city, such as New York City, would eventually turn into a cement-filled woodland if it were not constantly maintained.

FIGURE 3.3

Primary Succession in Urban Areas Plants that grow through cracks in city sidewalks can also be described as pioneers of primary succession.



These young lodgepole pine trees have started growing after a devastating forest fire.

trees form a thick barrier near the ground. In addition, their dead leaves and branches pile up on the ground and form extra fuel for fires. When a fire does occur, it is hotter and more severe than usual. The fire destroys not only the deciduous trees but also the pines. It may end up as a devastating wildfire.

Although it may seem odd, frequent burning is essential to preserve many plant communities and the animals that depend on them. This is the reason the U.S. National Park Service adopted the policy of letting fires in national parks burn if they do not endanger human life or property.

This policy caused a public outcry when fires burned Yellowstone National Park in 1988, because people did not understand the ecology of fire-adapted communities. The fires later became an opportunity for visitors to learn about the changes in an ecosystem after a fire.



This firefighter is helping to maintain a controlled fire in South Dakota.

Critical Thinking

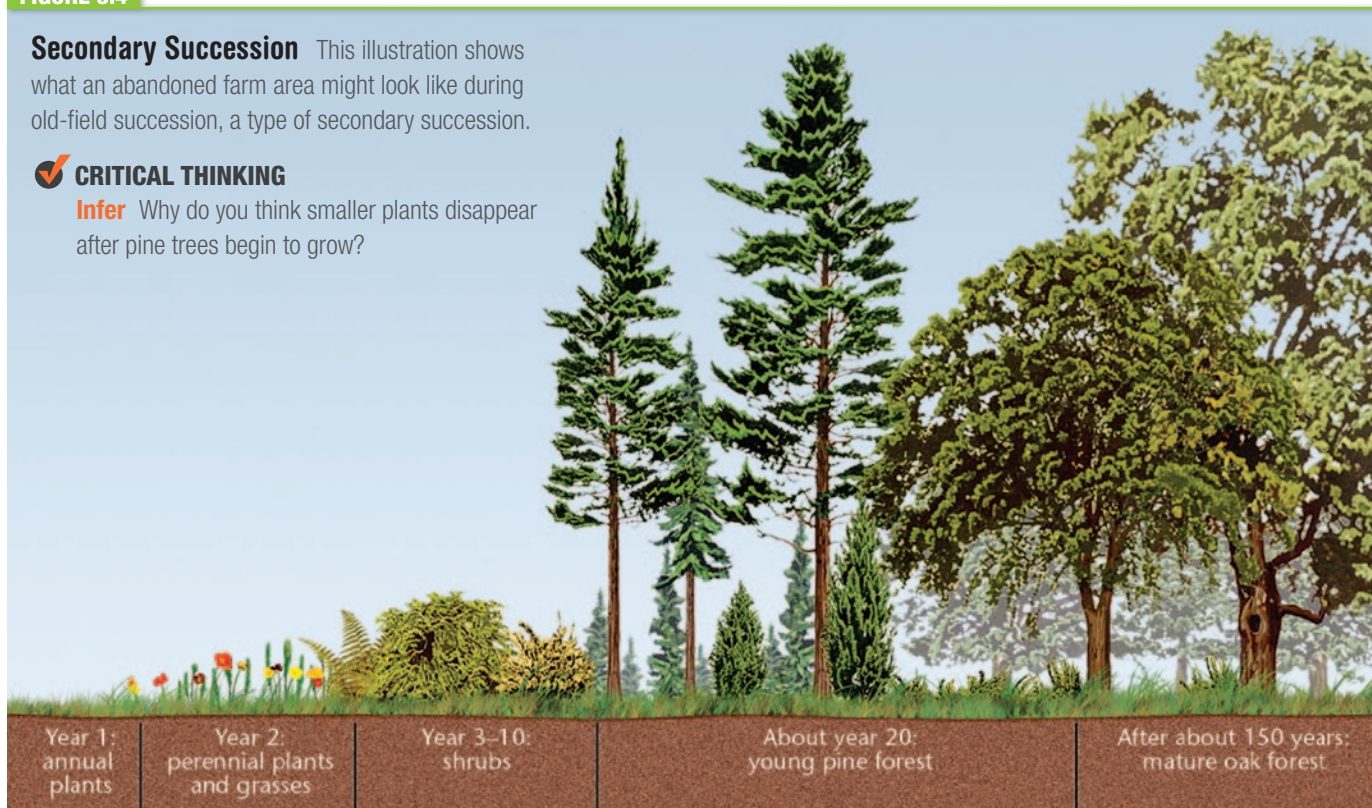
- 1. Understanding Processes** Explain how a longleaf pine tree might be more likely to survive a forest fire than a deciduous tree, such as a maple or oak tree.
- 2. Understanding Concepts** Why must controlled fires be set in some ecosystems? What are the advantages? What are the disadvantages?

FIGURE 3.4

Secondary Succession This illustration shows what an abandoned farm area might look like during old-field succession, a type of secondary succession.

CRITICAL THINKING

Infer Why do you think smaller plants disappear after pine trees begin to grow?



Secondary Succession

When a community is partially or completely destroyed by a natural or a human-caused disaster, another community eventually takes its place. For example, when fire destroys a forest, new communities begin to grow in place of the old ones. Pioneer species colonize the area first and, over time, more stable species become established. A **climax community** is a final and stable community. Even though a climax community continues to change in small ways, this type of community may remain the same through time if it is not disturbed.

Old-field Succession

When farmland is abandoned, a type of secondary succession called *old-field succession* occurs. When a field is no longer cultivated, pioneer species such as grasses and weeds quickly grow and cover the abandoned land. The grasses and weeds produce many seeds to cover large areas. Over time, taller plants grow in the area and shade the ground, keeping light from the shorter plants. The long roots of the taller plants also absorb most of the water in the soil. The pioneer plants soon die from lack of sunlight and water. As succession continues, growing trees deprive the taller plants of light and water. Finally, slower-growing trees, such as oaks, hickories, beeches, and maples, take over the area and block sunlight to the smaller trees. As shown in **Figure 3.4**, the area can eventually establish a climax community dominated by a mature oak forest. The field in **Figure 3.5** was once used as farm land, but has since been abandoned.

FIELDSTUDY

Go to Appendix B to find the field study **Investigating Succession**.

FIGURE 3.5

Old-Field Succession This field was once plowed, but has since been abandoned for one or more growing seasons. It is slowly becoming forested land.



Fire and Secondary Succession

Fires caused by lightning are a natural cause of secondary succession in some communities, as discussed in the Case Study. Some species of trees, such as the Jack pine, can release their seeds only after they have been exposed to the intense heat of a fire. Minor forest fires remove accumulations of brush and deadwood that would otherwise contribute to major fires that burn out of control. Fire is important in helping forests return nutrients to the soil. Secondary succession uses these nutrients to grow. After a fire, heavy growth of small plants near the ground often occurs and new trees flourish. Some animal species also depend on occasional fires because they feed on the vegetation that sprouts after a fire has cleared the land. Therefore, foresters sometimes allow natural fires to burn unless the fires are a threat to human life or property.



CHECK FOR UNDERSTANDING

Identify List two ways that fire can be beneficial to a forest community.

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Section 3 Formative Assessment

Reviewing Main Ideas

1. **Compare** primary and secondary succession.
2. **Describe** what role a pioneer species plays during the process of ecological succession.
3. **Explain** why putting out forest fires may be damaging in the long run.
4. **Describe** the role lichens play in primary succession. Write a short paragraph to explain your answer.

Critical Thinking

5. **Analyzing Processes** Over a period of 1,000 years, a lake becomes a maple forest. Is this process primary or secondary succession? Explain your answer.
6. **Analyzing Relationships** How are lichens similar to the pioneer species that colonize abandoned farm areas? How are they different?